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Which smartphone's apps may contribute to road safety? An AHP model to evaluate experts' opinions

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ABSTRACT

Smartphone usage while driving is a worldwide phenomenon which is acknowledged as a major concern for road safety. While being a major cause of risk, smartphones apps may also serve as a means to control and reduce risky driving behavior. However, it is still unclear which apps should be favored and what features and functions compose such valuable apps. The purpose of this paper is to establish a blueprint for smartphone apps that will have the greatest potential to reduce injury crashes. The study is based on apps mapping and experts' opinions retrieved through an Analytic Hierarchy Process (AHP). Thirty seven experts participated in the study and evaluated and graded nine widespread types of apps according to various criteria. When weighing safety considerations versus acceptance concerns, they were found to be almost equally important. The results clearly define the desirable types of smartphone apps: collision warning, texting prevention (both no-typing and no-reading), voice control (both text-to-speech and commands), and Green Box (In Vehicle Data Recorder – IVDR). However, while texting prevention and IVDR are not likely to be widely accepted and used, collision warning and voice control apps are expected to gain public support.

1. Introduction

Smartphone usage while driving is a worldwide phenomenon which is acknowledged as a major concern for road safety (NHSTA, 2013a; WHO, 2011). In the USA, during 2013, 424,000 people were injured in car crashes involving distracted drivers, and 3154 people were killed, among them 445 (14%) fatalities involved cell phone use (NHTSA, 2015). Ever since mobile phones have become an integral part of modern life people cannot imagine how one can live without it (Vincent, 2015) thus this issue will remain prominent in road safety.

Research indicates the risks associated with using smartphones while driving such as: texting, surfing the web, getting notifications from social networks, and even making phone conversations, all may lead to a distraction from the primary task of driving. The distraction may be multifaceted: visual, manual, audio, cognitive, and often, a combination of those distraction types. Consequently, the driver's ability to detect and attend to roadway stimuli and events is reduced (Caird et al., 2008; Fitch et al., 2013; Handel et al., 2014; Klauer et al., 2014; Strayer et al., 2013). Recent studies investigated driving distractions and confirmed the harmful effects of phone-related activities on driver performance. Of the many types of mobile device use, texting was found to be the most risky behavior (Dingus, 2014; Hedlund, 2011; Klauer et al., 2014; Victor et al., 2014).

Absurdly, the public perceives smartphone usage while driving, and especially texting, as significantly compromising safety, but these views are not associated with actual driving behavior (Hamilton et al., 2013; Marcoux et al., 2012; Musicant et al., 2015a). Various countermeasures from diverse disciplines have been suggested and implemented to try to mitigate the negative effects of smartphones usage while driving. Among them: legislation which forbids the use of hand-held cellphones, bans on texting, enforcement, generating “texting zones” along freeways, education, massive campaigns, and even recommendations to carmakers to limit the communication with electronic devices built into their vehicles (such as: surfing, entertainment and texting). However, there is an on-going discussion on the feasibility of implementing

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such measures, their effectiveness and their acceptability. Hence, the unsafe use of smartphones while driving continues to pose a serious risk to safety (Abouk and Adams, 2013; Goodwin et al., 2013; Kircher et al., 2012).

While being a major cause of risk, smartphones apps may also serve as a means to monitor, control and reduce risky driving behavior. A recent study (TRL et al., 2015) investigated which'best practice' approaches should be used to reduce road injuries caused by distracted driving. Clearly, technologies are evolving rapidly and the greatest advantage of smartphone apps as countermeasures is their low cost and wide availability. This can be tailored to specific purposes and used to influence patterns of smartphone usage while driving. However, the usage of apps is voluntarily and most importantly: it is still vague and unclear which types of apps should be favored and what features and functions compose a "safety suit" app. Furthermore, its prospects for drivers' acceptance and adoption should also be considered.

In this paper we describe a study aiming to establish a blueprint for smartphone apps by highlighting the desired types and features of apps which may have the greatest potential to reduce injury crashes, and hence, to contribute to road safety. It is based on evaluation of experts' opinions regarding various types of apps with respect to key criteria. The paper is organized as follows: In the next section we present the apps' mapping and describe the various types of apps and their possible benefits for safety. In the following sections, we illustrate the framework of the AHP and describe the experts study and the evaluation procedure. Then we present and analyze the results. Finally, we summarize and discuss.

2. Apps mapping

An extensive mapping of smartphone apps with indication regarding their potential benefits for safety was conducted. A total of approximately 250 apps, already in the market, were mapped and categorized according to their features. The mapped apps can be categorized according to the following three types: blocking apps, apps that change the interface with the user and driving-feedback apps. We would like to note that the 'three types' distinction is safety-oriented and takes into account drivers' modality (visual, auditory) and responses (manual, vocal). One can also create classifications based on the expected acceptability, social support, motivations for use and more.

The first type – blocking apps – relates to apps that prevent or limit the driver from using common features of the mobile phone such as: calling, typing, reading and prevention of various notifications (NHTSA, 2013b; Stothart et al., 2015; Waddell and Wiener, 2014).

To the best of our knowledge, little research has been done to investigate the effectiveness of such "blocking" apps (Funkhouser and Sayer, 2013; Vegega et al., 2013). In Benden et al. (2012) a literature review on cell phone use while driving was conducted. It was reported that only limited information regarding how to control texting while driving exists. Of all 74 reviewed articles, only 13 mentioned texting while driving as a specific driving behavior. It was also suggested to conduct further research pertaining to essential techniques to minimize risky behaviors in an increasingly technology dependent world (e.g., cell phone blocking devices).

The second type includes apps which present less distracting interface by enabling "Eyes on the road hands on the wheel". This is accomplished through: voice controls, heads up displays (HUDs) and hand gestures control. The effect of "voice-control" interface on driver behavior was investigated in numerous studies (Eriksson et al., 2014; He et al., 2013; Mehler et al., 2015; Reimer and Mehler, 2013; Reimer et al., 2015; Yager, 2013) and it seems to be concluded that voice interfaces are not necessarily free of visual-manual demands on attentional resources. Voice control includes either voice-to-text (V2T) or text-to-speech (T2S) interface. Advantages of V2T interface compared to manual interface were reported (He et al., 2013; Shah, 2013; Terken et al., 2011; Yager, 2013). The benefits of the T2S interface were also discussed (Brumby et al., 2011; Morris et al., 2014). In Owens et al. (2011) it was found that texting using an in-vehicle system can improve performance (steering measures) compared to handheld phone but still requires more task-related interior glance time and higher mental demand than baseline drive. T2S for incoming messages showed no differences from baseline.

HUDs are transparent displays which superimpose information directly on the driving scene. On one hand they do not require the driver to divert his/her eyes away from the road, but on the other, they provide limited field of view, super-imposition of multiple information channels and restricted boundaries within the windshield. Several studies presented combined interfaces of speech input and HUD visual output (Wang et al., 2014), or hand gestures as input with HUD visual output (Farooq et al., 2014; Lauber et al., 2014). In Jakus et al. (2015) it was concluded that visual and audio-visual HUD interface is faster and more efficient than audio-only display. Although no significant difference between the visual only and audio-visual displays in terms of efficiency and safety was found, most participants preferred the multi-modal interface while driving. Gestures control enables a natural interface for drivers, to interact with devices by hand movements, without direct physical contact. Gesture apps have the potential to reduce visual distraction, and was found preferable to touch interface in a simulator (May et al., 2014), during real driving (Loehmann et al., 2013) or in both (Parada-Loira et al., 2014).

The third type – driving feedback and coaching apps – are safety-oriented apps which provide, similar to In-Vehicle-Data-Recorder (IVDR), also known as Green Box, indications about unsafe and aggressive behaviors (Musicant et al., 2015b), collision warnings on short headways and lane keeping, fatigue detection and unexpected weather conditions (Blower, 2014). In Blower (2014) the current state of knowledge regarding advanced collision-avoidance technologies was reviewed and found to be substantially effective in reducing their target crash types. The results are limited due to low penetration rates in some of the cases. Birrell et al. (2014) reported significant increase in mean headway in a real-world on-road driving trials implementing short headways warnings. There was no difference in lane keeping parameters between a control group and the experimental group, suggesting that the drivers were not distracted when using the lane keeping warning system. A smartphone-based alternative for Advanced Driver Assistance Systems (ADAS) was proposed in Fazeen et al. (2012). The advantage of such device relies on its accessibility and portability, bringing assistance to any in-vehicle system regardless of its communication requirements, and complementing any existing active safety features.

3. The framework of an AHP model

The general framework of the AHP model which served as the outline for the experts' evaluation is illustrated in Fig. 1. The ultimate goal of the AHP (illustrated at the top of the figure) was to evaluate the potential of the various apps to reduce injury crashes and therefore the apps (illustrated at the bottom) have been defined and evaluated according to key criteria (illustrated in between). This framework has been adopted after numerous iterations aimed to outline the relevant key criteria.

The criteria were: (1) Risky driving behavior – the potential of